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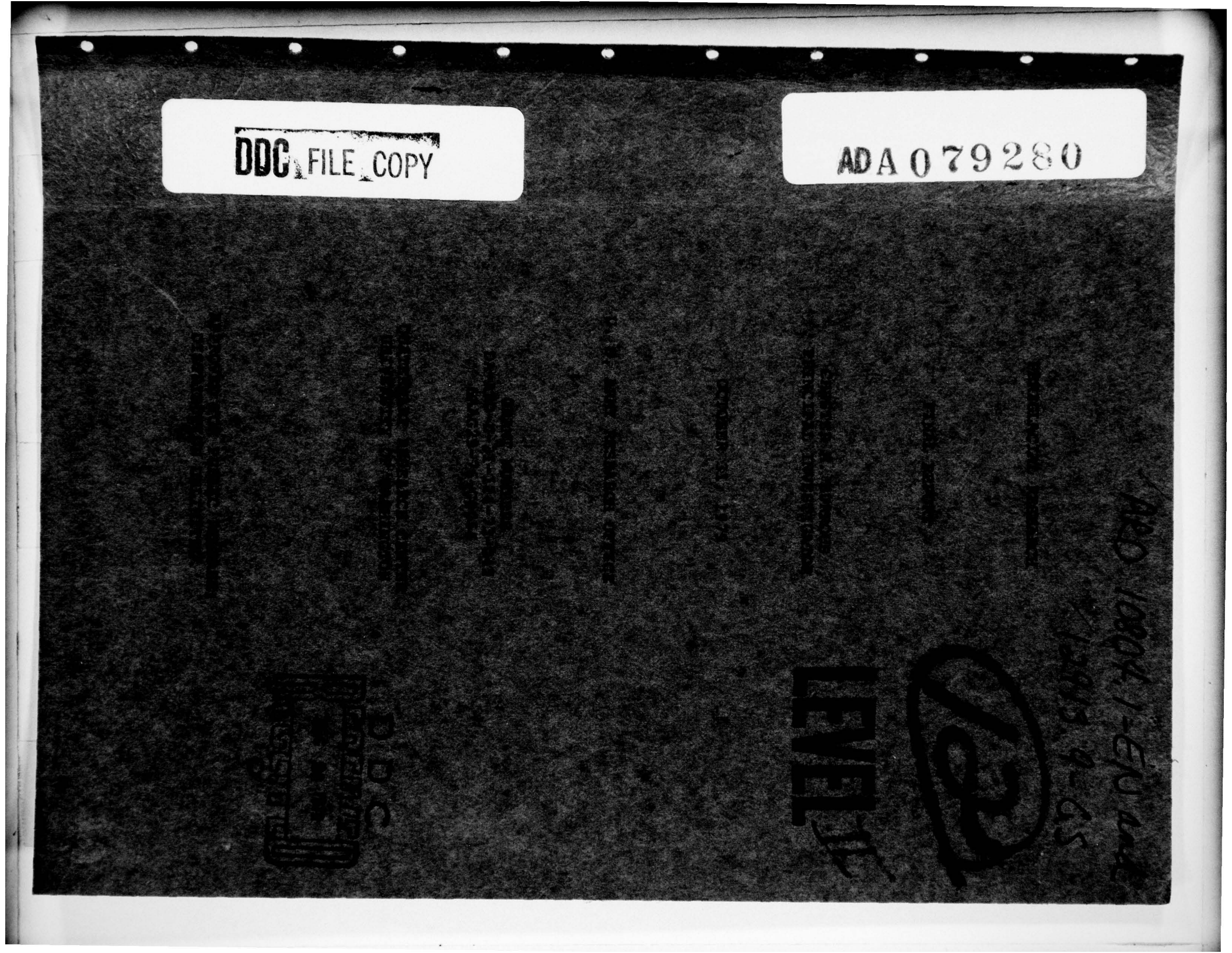

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18. SUPPLEMENTARY NOTES

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Frost Action, Frost Heave, Gelifluction, Heaving Pressure, Ice Segregation, Nuclear Magnetic Resonance, Periglacial Soil Deformation, Solifluction, Upfreezing.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The overall program has focused on the study of frost-action processes. Contributions to date are summarized below.

Periglacial Deformation Structures. Experiments conducted in a 2.5 x 3.6 m slab during freeze-thaw cycles have shown that deformation structures can develop where different soils abut each other.

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Block 20, continued.

Unfrozen Water Content. In cooperation with U. S. Army CRREL, pulsed nuclear magnetic resonance (NMR) techniques have been developed and utilized to determine phase composition curves of frozen soils.

Uplift of Objects by Ice Surfaces. Study of objects resting upon an upfreezing ice surface show that: 1) a wide variety of objects can be uplifted; 2) substantial heaving pressures can be generated; 3) uplift by an ice surface can be explained by ice segregation theory; and 4) the observations on uplift have theoretical, field, and applied implications.

Gelifluction (Periglacial Solifluction). Gelifluction produced on an essentially natural scale in the laboratory's 2.5 x 3.6 m tilting slab shows that slope motion is strongly influenced by ice distribution and rate of thaw.

Upfreezing of Objects. Experiments on the upfreezing, in silt, of glass objects of various sizes, shapes and orientations: 1) support the frost-pull hypothesis, and 2) indicate that the heave rate of objects is strongly related to their size and geometry.

PERIGLACIAL RESEARCH

FINAL REPORT

CHESTER M. BURROUS
PRINCIPAL INVESTIGATOR

OCTOBER 31, 1979

U. S. ARMY RESEARCH OFFICE

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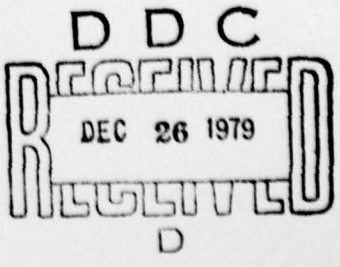

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THE FINDINGS IN THIS REPORT ARE NOT TO BE CONSTRUED AS AN OFFICIAL DEPARTMENT OF THE ARMY POSITION, UNLESS SO DESIGNATED BY OTHER AUTHORIZED DOCUMENTS.

FOREWORD

The funding of the Periglacial Research Laboratory has been about equally divided between the Army Research Office and the National Science Foundation. The initial grant years were necessarily largely devoted to equipping the laboratory (except for the tilting slab that gave the Laboratory its unique character), testing experimental procedures, and getting the research program underway; the subsequent years were consequently the more productive ones.

Following Dr. Washburn's retirement to Emeritus status, Dr. Burrous was appointed Technical Director of the Laboratory. Dr. Bernard Hallet, presently at Stanford University, will be joining the University of Washington next year to assume the Directorship of the Laboratory.

ABSTRACT

PROBLEMS STUDIED

The problems studied comprised various forms of frost action in soils, including deformation, upfreezing of objects, and slope movements during freezing and thawing; uplift of objects by ice surfaces during freezing; and determination of unfrozen water content of frozen soils.

ABSTRACT

SUMMARY OF MOST IMPORTANT RESULTS

Deformation Structures. Experiments conducted in the 2.5 x 3.6 m slab have provided new data on soil deformation during freeze-thaw cycles. It was shown that variation in cover materials can lead to deformation structures in soils along or near their contact, probably due to offset of freezing and thawing fronts. The deformation produced included vertical breaks, apparently caused by shearing, and involutions ("pocket structures") presumably caused by density differences during thaw.

Unfrozen Water Content. In cooperation with U. S. Army CRREL, pulsed nuclear magnetic resonance (NMR) techniques have been developed and utilized to determine phase composition curves of frozen soils (i.e. curves of unfrozen water content versus temperature). This promising technique offers advantages in speed, convenience, and in the wide range of temperatures in which water contents of different soil types can be studied. It was demonstrated that this technique gives a high degree of reproducibility and is consistent with other established methods.

Uplift of Objects by Ice Surfaces. Recent experimental work on the vertical transport of an object resting upon an upfreezing ice surface have shown that: 1) a wide variety of objects can be uplifted; 2) substantial heaving pressures can be generated; 3) uplift by an ice surface can be explained by ice segregation theory; and 4) the observations on uplift have theoretical, field, and applied implications.

Gelifluction (Periglacial Solifluction). Gelifluction has

been produced on an essentially natural scale in the laboratory's 2.5 x 3.6 m tilting slab. It has been shown that slope motion is strongly influenced by ice distribution and rate of thaw. In particular, the experiments clearly indicated that periods of major soil motion coincided with periods when the thaw front was within the region of segregated ice. Further, most of the subsurface strain was confined to the icy region.

Upfreezing of Objects. Experiments on the upfreezing, in silt, of glass objects of various sizes, shapes and orientations: 1) support the frost-pull hypothesis, and 2) indicate that the heaving rates of objects are strongly related to their projected height (or vertical dimension) despite other geometric differences.

PUBLICATIONS

Mackay, J. R. and Burrous, C. M., 1979, Uplift of objects by an upfreezing ice surface: Canadian Geotechnical Journal, vol. 16, no. 3, p. 609-613.

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Publications in Preparation or Submitted

Burrous, C. M., Experimental upfreezing of objects: Effects of object geometry. (In preparation.)

Mackay, J. R., Model experiments on the growth of pingos and frost mounds. (In preparation.)

Rein, R. G., Jr., and Burrous, C. M., Laboratory measurements of subsurface displacements during thaw of low-angle slopes of a frost-susceptible soil. (Submitted to Arctic and Alpine Research.)

PARTICIPATING SCIENTIFIC AND TECHNICAL PERSONNEL

Dr. Amos Banin

Dr. Chester M. Burrous

Dr. C. H. Hendy (not salaried by program)

Dr. Akira Higashi

Dr. Mehmet Sherif (not salaried by program)

Dr. Robert G. Rein, Jr.

Mr. Allen Tice (not salaried by program)

Dr. Fiorenzo Ugolini (not salaried by program)

Dr. A. L. Washburn (not salaried by program)

Mr. Chad Canty (Technician)

Ms. Jan Frederick (Student employee)

Mr. David Grey (Technician)

Mr. Jun Hiyakawa (Technician)

Mr. (now Dr.) Thomas Pierson (Student employee)

The Quaternary Research Center does not award degrees. However, the following students received degrees in other departments, based in part on work accomplished in the Periglacial Laboratory. Although most of these students were not financed by the program, they could not have carried out their work without the presence of the Laboratory and the support it received from ARO and NSF.

Wing-Wai Ding	"Frost action in soils." (M.S., Civil Engineering, 1976)
Craig LaVille	"Creep of ice-rich silt in frozen soils" (M.S., Civil Engineering, 1979)

P. S. Marshall	"The linear coefficient of thermal expression for frozen clays." (M.S., Geological Sciences, 1977)
J. E. Perry, Jr.	"Frost susceptibility of soils." (M.S., Civil Engineering, 1974)
Ki-Ho Yoon	"Mineralogical effects on frost heave of soils." (M.S., Civil Engineering, 1977)